

**GROUNDWATER EXPLORATION
WEST OF CALLVILLE BAY
LAKE MEAD NATIONAL RECREATION AREA
CLARK COUNTY, NEVADA**

Terracon



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LAKE MEAD NATIONAL RECREATION AREA
CLARK COUNTY, NEVADA**

for: National Park Service

Project No. 64947206

June 13, 1995


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GROUNDWATER EXPLORATION
West of Callville Bay
Lake Mead National Recreation Area
Clark County, Nevada

Terracon

1.0 INTRODUCTION

Terracon Consultants Western, Inc., (Terracon) provided technical services and oversight for installation of a 200-foot deep exploration well in the vicinity of Callville Bay in the Lake Mead National Recreation Area (LMNRA) for the National Park Service (NPS) (Figure 1, Appendix A). This work was conducted in April 1995, in general accordance with Terracon's proposal dated September 23, 1994.

The exploration well was placed at the southeastern end of a peninsula located west of Water Barge Cove. A surface water intake barge, located in Water Barge Cove, which supplies water for Callville Bay Marina, was located approximately 1,000 feet northeast of the exploration well site. An existing gravel road provided access to the peninsula. A rough-cut road, which provided access to the well site, was constructed by the NPS.

2.0 OBJECTIVES

The objectives of this project as set forth by the National Park Service were to establish the feasibility of developing a public water supply from groundwater near Callville Bay, Nevada, which is located within the LMNRA. Aquifer yield and water quality were to be defined. Water quality criteria needed to meet all mineral and biological parameters as set forth by the Safe Drinking Water Act (SDWA).

3.0 SCOPE OF WORK

The scope of work consisted of the following four tasks:

- Geological reconnaissance;
- Exploration well drilling;
- Well logging and aquifer testing;
- Laboratory testing.

3.1 Water Well Siting Investigation

The results of the first task were presented in Terracon's Water Well Siting Investigation Report, dated March 22, 1995. (Appendix B). Based on the results of the geologic reconnaissance, two potential exploration well sites were identified. The criteria used for selection of the exploration well site were as follows:

- Aquifer materials consisting of permeable cemented gravels and avoidance of fine-grained low yielding (1-2 gpm) materials encountered elsewhere on the peninsula.
- Proximity of the well site to the lake shore so that water derived from the lake would be stored in aquifer materials so as to prevent an excessive increase in the total dissolved solids (TDS) concentrations, yet still provide the necessary filtration to remove microorganisms.
- A source of lake water with fewer populations of microorganisms; this criterion was thought to be best met at the southern end of the peninsula where lake water has greater circulation as compared to the area to the north.

4.0 EXPLORATION WELL DRILLING

A 9 7/8 inch (in) exploratory drillhole was advanced using air/foam to 200 feet (ft) below ground surface (bgs) with a SS16 Speed Star air-rotary mobile drill rig. The drill rig was a 3-axle unit equipped with a 1,000 CFM/250 PSI air compressor. The fluids for the foam consisted of potable water derived from a public water supply in Henderson, Nevada, and a biodegradable chemical foaming agent produced by Thatcher Chemical Company, in Salt Lake City, Utah, and referred to as "Surfactant". The cuttings were left on-site with the approval of the National Park Service. The cuttings were logged by a Terracon geologist at 10 foot intervals. A lithologic log is provided in Plate A, Appendix C. The Nevada Division of Water Resources issued a waiver, No. W-2064, on April 24, 1995, which authorized the NPS to drill the exploration well (Appendix D).

National Park Service
Groundwater Exploration
Project No. 64947206

4.1 Well Construction, Well Development and Aquifer Testing

The drillhole was airlifted for one-half hour after drilling on April 7, 1995. On April 8, 1995 200 feet of 6-in steel casing with welded joints was installed in the completed borehole. As shown in Plate C (Appendix C) perforated intervals consist of one 35-foot section and one 5-foot section installed between the intervals of 125 to 160 feet and from 175 to 180 feet, respectively. The perforated steel casing had 12 slots per foot and each slot was factory cut with 1/8 inch by 2 1/2 inch slots.

Centralizers were welded onto the casing and installed at depths of 40, 100, 160 and 190 feet bgs. The centralizers were used to keep the casing plumb in the borehole and allow 1/4 to 1/8 inch gravel to fill the annular space around the casing. A sanitary seal cement (grout) was installed from 50 to 2 feet bgs.

On April 12, 1995, after well construction, the well was developed by pumping at a rate of approximately 100 gallons per minute (gpm) for a period of 3 hours. The water was monitored for clarity during pumping. At the end of the pumping interval, the water was clear. Static water level measured 0.5 hour after development was 93.3 feet bgs.

On April 12 through 13, 1995, a constant rate aquifer test was performed for a period of 24 hours (Appendix E). Drawdown, temperature, conductivity, pH, and sand content were monitored during the aquifer test. These parameters, with the exception of pH, stabilized within a few hours of pumping at the following values:

- Temperature: initial 25.5 degrees Celsius stabilized at approximately 25 degrees Celsius;
- Conductivity: initial 865 μ mhos per centimeter and stabilized 883 μ mhos per centimeter;
- Sand Content: initial a trace amount settled out of a 1-liter graduated cylinder, final - a trace amount settled out of a 1-liter graduated cylinder, and
- pH: initial 8.8 for the first three hours of the aquifer test, and stabilized at 6.9 for the remainder of the aquifer test.

A 7.5 horsepower submersible pump was set at a depth of 150 feet within the perforated interval. The initial pumping rate was 100 gpm that steadily decreased over the next 5 hours to approximately 70 gpm. The flow rate was measured with a totalizing flow meter. Approximately 8 hours into the test the flow meter failed. After that, the flow rate was approximated by measuring the time that it took to fill a 5-gallon bucket. At the time of the flow meter failure, 38,000 gallons of water had been pumped. Based on additional flow measurements taken by the bucket and stopwatch method, approximately 100,000 gallons of groundwater were pumped over 24 hours. Water levels were monitored using an airline pressure gauge and verified at the end of the test with a Solinst™ water level indicator. The water pumped from the well during development and testing, was discharged onto the ground surface.

4.2 Well Sampling and Analytical Methods

Groundwater samples were collected from the outflow directly into appropriate containers provided by Nevada-certified Nevada Environmental Laboratory (NEL) in Las Vegas, Nevada. The samples were stored with ice in a cooler to maintain an approximate temperature of 4 degrees Celsius. The groundwater samples were transferred under proper chain-of-custody to NEL for analysis. NEL analyzed for primary and secondary drinking water standards (inorganic and general mineral content, turbidity, and bacteria) recognized by the Safe Drinking Water Act (SDWA). The analytical report is presented in Appendix F and the results are tabulated in Table 1 (Appendix G).

A sample was sent to CH Diagnostic and Consulting (CH Diagnostic) in Loveland, Colorado for Microscopic Particulate Analysis (MPA) by the "EPA Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using MPA Analysis." MPA assesses the potential surface water contribution to groundwater. CH Diagnostic is one of the few laboratories in the country presently certified for this method. The sampling equipment, instructions and sample container were provided by CH Diagnostic. The sample was submitted via overnight delivery, under proper chain-of-custody, to CH Diagnostic for analysis. The analytical report is presented in Appendix H and the results are tabulated in Table 1 (Appendix G).

The results of the groundwater sampling were submitted to Mr. David Hunt, P.E., Public Health Engineer, with the Nevada Department of Human Resources, Bureau of Health Services in Carson City. Mr. Hunt's response is discussed in Section 5.3.

5.0 RESULTS

5.1 Exploration Well Drilling

The boring was drilled to depth of 208 feet, at an average rate of penetration of 0.8 feet per minute. Cemented gravels, interpreted to be from the Cemented Gravel Unit of the upper Member of the Quaternary-Tertiary Older Alluvium, were encountered from a few feet below ground surface to approximately 100 feet bgs. Silts, sands and gravels, interpreted to be from the Tertiary Horse Spring Formation, were encountered from 100 to 208 feet. Groundwater was encountered during drilling at a depth of approximately 110 feet bgs. On the following day, April 8, the static water level was 93 feet bgs.

5.2 Aquifer Testing and Analyses

A 24-hour constant rate aquifer test was conducted from 1:05 pm, April 12 through 1:05 pm, on April 13, 1995. Static water level measured at the start of the test was 93.3 feet bgs. The initial drawdown was 25 feet bgs with a maximum of 27 feet after 75 minutes of pumping at a rate of 100 gallons per minute. Subsequently, the drawdown decreased to 20 feet bgs and the flow rate decreased to 70 gpm after approximately 7 hours of pumping. The final drawdown was measured at 13.8 feet bgs. The final pumping rate was estimated at approximately 50 gpm. The decreasing pumping rate was attributed to a submersible pump malfunction rather than due to aquifer response.

The groundwater level returned from 107.1 feet bgs at the end of the aquifer test to the initial static water level 93.3 feet bgs within four minutes.

A quantitative analysis of the first 105 minutes of the constant rate aquifer test, at the 100 gpm pumping rate, was performed using Geraghty & Miller, Inc.'s, ground-water monitoring software, Aqtesolv, version 2.0. The data was analyzed using the "Hantush Leaky Aquifer Test Method, with storage in the aquitard" and the "Hantush Leaky Aquifer Test Method, with no storage in the aquitard". Only the data collected during the first 105 minutes of the constant rate aquifer test were used. During this period of time the pump was operating at a rate of 100 gpm. After 105 minutes, the pump rate decreased and data obtained during variable rates of pumping, after 105 minutes of pumping, could not be used for this analysis.

Based on the results of the analyses, the estimated range of transmissivity, is 1 to 0.5 square feet per minute for the aquifer materials. Graphs illustrating drawdown versus time during the constant rate pump test are provided in Appendix I. The estimated range of aquifer storativity from the analysis is 4×10^{-9} to 9×10^{-9} . Storativity values for leaky and confined aquifers are typically less than 10^{-4} , but generally are not as low as 10^{-9} . Storativity values are likely between 10^{-4} and 10^{-9} . Transmissivity and storativity are used to predict aquifer response to pumping. The calculated range of daily yields, based on the transmissivity values for 100 feet of saturated sediments, are 9,800 gallons per day (gpd) to 19,500 gpd. The maximum flow rate measured in the field was 100 gpm with a maximum drawdown of 27.7 ft.

5.3 Water Quality

The groundwater was analyzed for primary and secondary drinking water standards which included inorganic and general mineral, turbidity, bacteriological sampling and for MPA. Parameters near or greater than the maximum contaminant levels (MCLs) for primary drinking water standards or the secondary drinking water standards (both primary and secondary standards are referred to as MCLs in this report) (Table 1, Appendix G) are listed as follows:

- Nitrate as Nitrogen;
- TDS;
- Chloride;
- Sulfate;
- Turbidity;
- Total Coliform;
- Iron;
- Amorphous Debris, Other Algae and Diatoms were present.

A written opinion from Nevada State Health Division, Bureau of Public Health Engineering concerning the interpretation of MPA analysis results and other comments on acceptability of

the water quality relative to the SDWA standards are provided in Appendix J. A summary of the state's response is provided as follows:

1. What additional water treatment, if any, might apply?

"Community water systems must provide water that meets all primary drinking water standards as contained in Nevada Administrative Code (NAC) Chapter 445, Public Water Systems Quality. Exceedance of a primary or secondary standard may require public notification, treatment, and/or additional monitoring."

2. What are the variance procedures, if any, to allow use of the water despite it not meeting certain secondary standards?

"The State Board of Health may grant a variance or exemption from a primary drinking water standard in accordance with NAC Chapter 445, Public Water Systems Quality. The State Board of Health may grant a variance from a secondary drinking water standard in accordance with the procedures for seeking variances set forth in chapter 439 of NAC."

3. Does the groundwater developed from this well appear to be under the direct influence of surface water?

According to the State the well appeared to be under the direct influence of Lake Mead. However, the determination that the groundwater is under the direct influence of surface water, cannot be based on the results of one MPA.

6.0 CONCLUSIONS

- Results of the exploration geologic reconnaissance, based on literature review, geologic mapping, and review by U.S. Geological Survey personnel, suggested a suitable location for a test well. The intended aquifer zone was the cemented alluvium but the test drilling results indicated that this unit graded into the Horse Spring Formation at depth. The screened interval was located within the Horse Spring Formation, not the Cemented Gravel Unit of the Older Alluvium, as originally intended. Local conditions in the area drilled indicated that future

wells could be placed inland farther from the influence of Lake Mead and within the Horse Spring Formation, but there is still a significant risk that water pumped from this formation would have high TDS levels.

- Production of groundwater at 70 gpm to 100 gpm was limited due to pump output. The calculated transmissivity and field observations suggest permeable aquifer materials that could produce more than 100 gpm per well;
- Several inorganic and organic parameters are close to or exceed the MCLs for drinking water.
- If the groundwater source is determined to be under the direct influence of surface water, the source would be subject to the requirements of NAC Chapter 445, Public Water Systems Surface Water Treatment Rule.

7.0 RECOMMENDATIONS

- Future exploration wells should be placed in the gravel zones of the Horse Spring Formation.
- If possible, collect additional groundwater samples from the existing well during the seasonal high and low lake water levels to assess the influence of Lake Mead, in accordance with the Bureau of Health Protection's recommendations.

8.0 GENERAL COMMENTS

The analyses and opinions expressed in this report are based upon data obtained from soil borings at the indicated locations and from other information discussed in this report. This report does not reflect any variations in subsurface stratigraphy, geohydrology, or contaminant concentrations which may occur between boring sample locations. Actual subsurface conditions may vary and may not become evident without further exploration.

This report was prepared for the exclusive use of the National Park Service for specific application to the subject project and has been prepared in accordance with generally accepted environmental practices. No warranties, either express or implied, are made or intended. In the event that any changes in the nature or location of suspected sources of

contamination as outlined in this report are observed, the conclusions and recommendations contained in this report shall not be valid unless these changes are reviewed and the opinions of this report are modified or verified in writing by Terracon Consultants Western, Inc.

TERRACON CONSULTANTS WESTERN, INC.

Reviewed by:

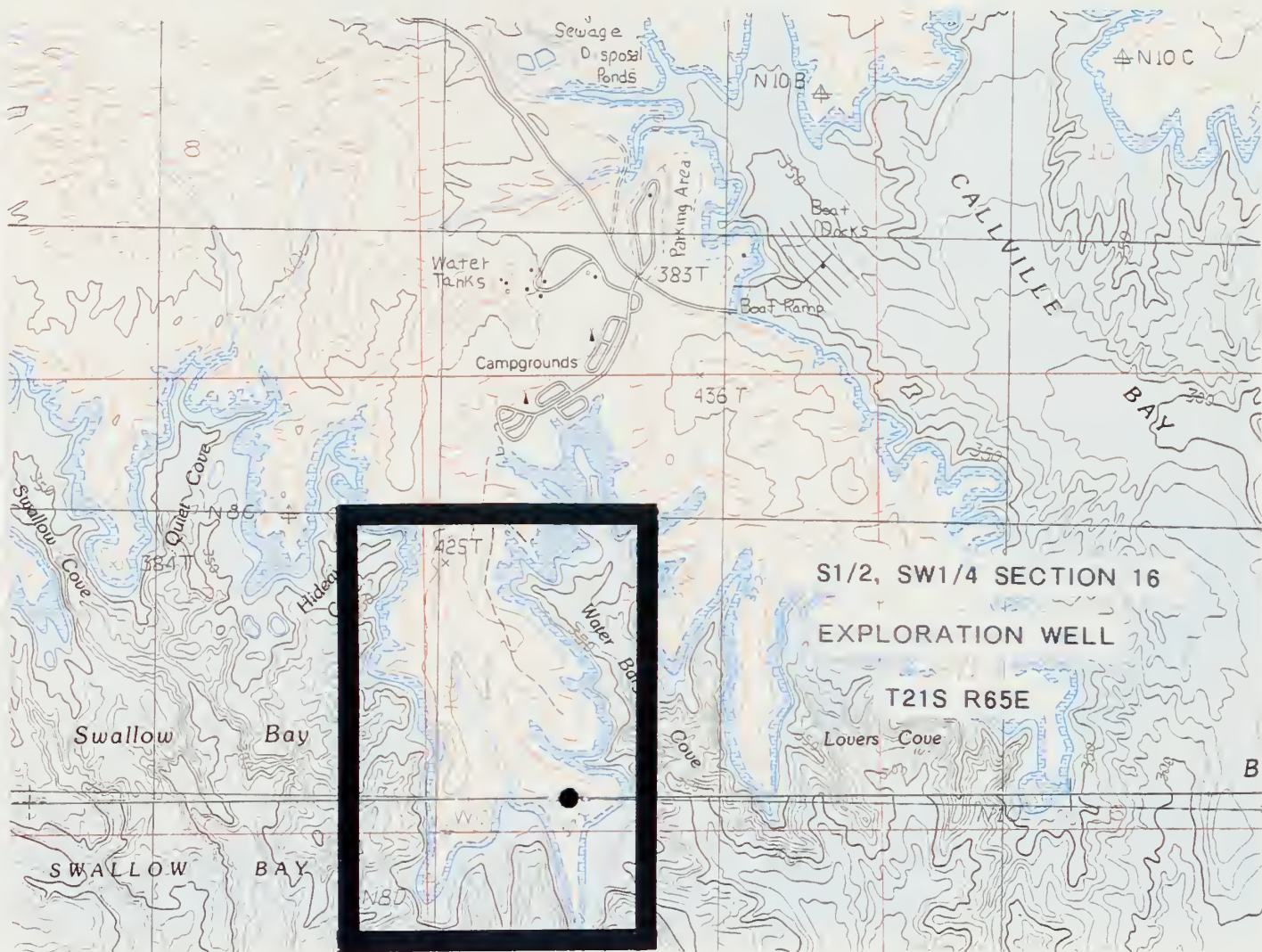


Delane P. Fitzpatrick, C.E.M. 1365
Project Hydrogeologist

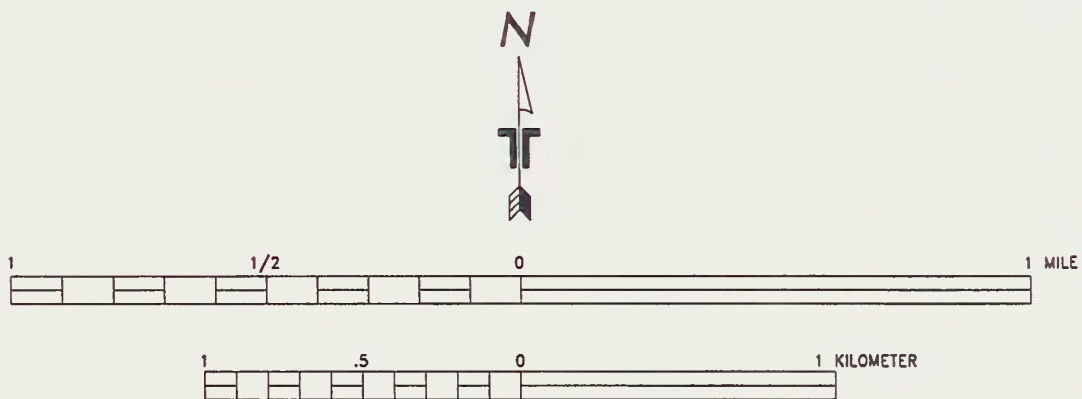


Robert F. Kaufmann, C.E.G., C.E.M. 1016
Vice President

DPF/RFK/cmc



Contour interval 20 meters, underwater contour interval 10 meters.



U.S.G.S. 7 1/2 Quodrangle Maps "Hoover Dam, Nev.-Ariz." and "Callville Bay, Nev.-Ariz."

CLIENT:
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LOCATION MAP

PROJECT NO.:
64947206

FIGURE:
1

March 22, 1995

United States Department of the Interior
National Park Service
Lake Mead National Recreation Area
601 Nevada Highway
Boulder City, Nevada 89005

Attention: Mr. Steven N. Spearman
Environmental Health Specialist

Re: Water Well Siting Investigation
West of Callville Bay
Lake Mead National Recreation Area
Nevada

Dear Mr. Spearman:

We are please to submit the results of our Water Well Siting Investigation pertinent to water supply development for the Callville Bay Area. This work was performed in accordance with our proposal of September 23, 1994.

Geologic conditions indicate that the most favorable well locations are in the southeastern portion of the peninsula located west of Water Barge Cove. The next phase of work, involving test drilling, aquifer testing, and water quality analysis, will be required to verify aquifer yield and water quality.

If you have any questions concerning information contained in this report, please contact us at your convenience. Thank you for the opportunity to be of service.

Sincerely,
TERRACON CONSULTANTS WESTERN, INC.



Robert F. Kaufmann, C.E.G., C.E.M.
Vice President

RFK/cmc

**WATER WELL SITING INVESTIGATION
WEST OF CALLVILLE BAY
LAKE MEAD NATIONAL RECREATION AREA
NEVADA**

for: National Park Service

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Water Well Siting Investigation
West of Callville Bay
Lake Mead National Recreation Area
Nevada

1.0 INTRODUCTION

The National Park Service (NPS) is assessing the feasibility of using groundwater as a public water supply source at Callville Bay Marina, in the Lake Mead National Recreation Area (LMNRA) of Nevada and Arizona. LMNRA receives over 8 million visitors a year and the potable water demands are increasing rapidly. The purpose of this project is to provide the NPS with information regarding the anticipated quantity and quality of potable groundwater available in this area. As part of the study, Terracon's is evaluating aquifer yield potential and water quality relative to standards set forth in the Safe Drinking Water Act.

Although the lake water has acceptable mineral quality, it contains microorganisms regulated by the USEPA Surface Water Treatment Rule. It is possible that filtration of lake water by aquifer materials could result in water not subject to this treatment requirement. However, groundwater recharge by lake water can result in excessive mineral concentrations due to the presence of sulfate and other soluble salts in the sediments. Accordingly, the overall exploration target is a well site with sufficient yield to meet water demand, acceptable mineral quality, and sufficient filtration to remove microorganisms. Laney and Bales (in progress) described the peninsula located west of Callville Bay as a likely location for a groundwater exploration well. The purpose of the investigation reported on herein is to map the principal geologic units present in the peninsula for the purpose of selecting a preferred test drilling location. Geophysical surveying was originally proposed but the geologic mapping indicates insufficient velocity or resistivity contrasts between the target aquifer unit and the underlying (unacceptable) strata. Therefore, geophysical surveys were deleted from the scope of the investigation.

Presently, water is pumped from the lake for public use. In the future, this water must undergo treatment to remove microorganisms prior to use. It is expected that a successful well would provide potable water not requiring filtration. Previous attempts to develop potable water supply wells in the LMNRA have been largely unsuccessful due to siting in mineralized strata or poor well construction. Should the present effort prove successful at Callville Bay, it may have application to other marinas within the LMNRA.

1.1 Location of Study Area

The study area is located within Sections 16, 17, 20 and 21, Township 21 South, Range 65 East, M.D.B.M. in Clark County, Nevada. The study site was located on a peninsula situated

between Water Barge Cove and Swallow Bay, in an area generally southwest of Callville Bay. The peninsula extends north to south approximately one mile and east to west a maximum of one-half mile. A graded gravel roadway constructed by the NPS provides access from the Callville Bay campground to the eastern portion of the peninsula. The roadway leads to the present NPS surface water supply source which is a barge-mounted pump located approximately 150 feet out from the shoreline. The location of the study area is depicted in Figure 1 (Appendix A) which is a portion of the U.S. Geological Survey 7.5 minute series topographical maps, "Callville Bay, Nev.-Ariz.", Provisional Edition 1983 and "Hoover Dam, Nev.-Ariz.", Provisional Edition 1983.

1.2 Previous Work

A series of hydrogeologic reconnaissance reports have been prepared by the U.S. Geological Survey, in cooperation with the NPS, for the LMNRA including both Lake Mead and Lake Mohave. Laney and Bales (in progress) prepared a geohydrologic reconnaissance report of Las Vegas Wash to Virgin River, Nevada, which is a portion of the LMNRA. This report is the last in the series of U.S. Geological Survey hydrogeologic reports for the LMNRA. Previous hydrogeologic reports for the LMNRA have been prepared by Bales and Laney (1992), Laney (1982, 1979a, 1979b, and 1979c), and Bentley (1979a, 1979b, and 1979c). The report by Laney and Bales (in progress) identified the (lake) water-saturated gravels on the peninsula west of Callville Bay as an area with potential for groundwater development. According to Laney and Bales (1992) the largest potential source of water in the LMNRA is from (lake) water-saturated sediments. Other potential sources of groundwater include groundwater in local basins, groundwater related to perennial streams, and springs in the Muddy Mountains. These sources may have deteriorated water quality relative to the (lake) water-saturated sediments. Additionally, there could be substantial costs with transmission and power supply. In the case of spring development, there could be additional, adverse effects on wildlife.

2.0 OBJECTIVES

Exploration for a potable water supply well will include the following:

- Geologic Reconnaissance;
- Exploration Well Drilling; and
- Lithologic Logging, Aquifer Testing, and Laboratory Testing.

Favored well site locations are near the lake shore and above the high water level at the southern portion of the peninsula. Preferred aquifer materials include older alluvial gravels and coarse-grained, ancestral Colorado River deposits. Permeable sediments with low concentrations of gypsum and other soluble minerals are of interest. The sediments may filter out microorganisms present in the lake water. This report describes the geologic reconnaissance and provides recommendations for further work.

The original Scope of Work called for use of both surficial geologic mapping and seismic geophysical techniques to select a test well location. The scope was modified to delete the geophysical surveys because of unsuitable subsurface conditions and, instead, add construction of a second exploration well.

3.0 GEOLOGIC RECONNAISSANCE

For both geologic and logistical reasons, the exploration area was limited to the peninsula west of Callville Bay. Considerations included drill-site accessibility, presence of coarse grained deposits, and proximity to recharge by lake water. Because of reduced circulation and attendant potentially higher microorganism populations at the north ends of Swallow Bay and Water Barge Cove, the well location search was further restricted to the central and southern portions of the peninsula near the open waters of the lake. An existing roadway constructed by the NPS provided access to part of the peninsula. Coarse grained older alluvial deposits were mapped by Laney and Bales (in progress) on the eastern portion of the peninsula. Although the extensive shoreline suggests a wide selection of potential drilling sites, access by drilling equipment and support vehicles is limited to selected areas unless there is substantial development of access roads and drilling pads. Such development has obvious cost and aesthetic drawbacks.

3.1 Site Geology

In ascending order, the principal geologic units in the peninsula area include the Horse Spring Formation, the Older Alluvium, and the Younger Alluvium. Of these, only the Older Alluvium units are of interest because they have the potential for favorable permeability, acceptable water quality, and sufficient saturation. The general occurrence of these units in the peninsula area is shown in Figure 2, Appendix A. Basically, the Horse Spring Formation is near lake level at the western side of the peninsula, whereas the Older Alluvium occurs beneath most of the remainder of the peninsula. The Younger Alluvium is not mapped

because it is a very thin unit in the present-day washes and of no hydrologic significance relative to the purpose of the present investigation. Regionally, the lithologic units dip slightly to the east.

The Older Alluvium is divided into two mappable units for the purpose of this report. These are the upper, generally fine-grained, poor to moderately cemented sediments of the Upper Unit of the Older Alluvium (Upper Unit) and cemented gravels of the Older Alluvium (Cemented Gravels). Both the Upper Unit and the Cemented Gravel Units dip gently to the east. Additionally, the cemented Gravels have been gently folded. Regionally the lithologic units dip slightly to the east. The Horse Spring strata are generally folded. A discussion of the geologic units observed in the field area is presented in the following sections.

3.1.1 Younger Alluvium and Cemented Alluvium

The younger alluvium consisted of silty sandy gravels, present in the base of the drainage washes. The thickness appeared to range from a thin veneer to an estimated 10 feet in the base of the main drainage wash. Because of limited areal extent and thickness and primarily because the unit is unsaturated, it was not separately mapped in this investigation.

Cemented alluvium capped the ridges in the field area (Photograph P-1, Appendix B). This carbonate-cemented alluvium generally consisted of silty sand and carbonate gravels and cobbles, with a trace amount of metamorphic gravels, chert, and basaltic lag boulders. The lag boulders were apparently of local origin, based on proximity to Callville Mesa. The cemented cap appeared to conformably overlie the Upper Unit and the cemented gravel unit in the north half of the study area.

3.1.2 Older Alluvium

Laney and Bales (in progress) in their hydrogeologic reconnaissance report, observed that Older Alluvium is divided into two units, the Upper and the Lower Unit. The two units were not continuous throughout the field area; therefore, the Upper and Lower Unit were mapped together as Older Alluvium. The Lower Unit was described as generally well cemented and coarser grained whereas the Upper Unit was characterized as having a higher percentage of fine grained material such as silts and sands.

During the field reconnaissance, the upper fine grained unit was identified and an overlying, well cemented gravel was also identified. Based on observed field relationships, the Cemented Gravels may: a) overlie the Upper Unit, b) be a facies of the Upper Unit, or c) be a fault contact. The relationship of the Cemented Gravels to the underlying Upper Unit is not well understood in terms of structural or stratigraphic relationships, but probably represents an erosional disconformity. Because of the significance of the Cemented Gravels as an exploration well target area, they were mapped separately.

The clasts observed in both of the mappable units were generally of the same composition, except that clasts in the Upper Unit appeared to be larger (boulders and cobbles) than those in the Cemented Gravel Unit (gravels). The Upper Unit and the Cemented Gravel Unit are described separately in the following sections.

3.1.2.1 Upper Unit

The Upper Unit generally trends north 50 degrees east and dips to the east approximately 5 degrees. This unit typically formed tan-colored vertical cliffs due to undercutting wave action in the beach zone (Photographs P-1 and P-2, Appendix B). At the cliff face on the southwestern end of the peninsula, steeper dips were observed in connection with an apparent high angle fault. This fault appeared to have only a minor amount of displacement which apparently occurred prior to and during the deposition of the upper portion of the Upper Unit. The Upper Unit consists of interbedded silt, silty sands with gravels, cobbles, boulders, and thin gravel layers. The clasts consisted of angular to subangular boulders and subangular to subrounded cobbles of carbonates, intermediate intrusives, schists, rounded river cobbles, a minor amount of red sandstone, and trace amounts of red and black chert. This unit was generally poorly cemented with occasional moderately cemented layers. Rounded river cobbles were concentrated in a layer located in the upper portion of this unit where it crops out along the western cliff face. These river cobbles were also identified in the northeastern portion of the study area along the access road. In the beach zone, large slump blocks consisting of poorly cemented sands with gravels had developed due to undercutting wave action.

According to Laney and Bales (in progress), the Upper Unit has a high gypsum content, and is generally fine grained.

3.1.2.2 Cemented Gravel Unit

The Cemented Gravel Unit was observed in the eastern portion of the peninsula where it consisted of moderate to well cemented gravels (Photograph P-1, Appendix B). Clasts consisted of subrounded to subangular carbonates, intermediate intrusives, red sandstone, ~~river cobbles~~, minor quantities of red and black chert, and schist. The unit was fractured. In Large slump blocks of cemented gravels characteristically developed due to undercutting wave action (Photograph P-1, Appendix B).

Strikes measured on the beds at the southern portion ranged between North 30 degrees West and North 22 degrees East with shallow (less than 20 degrees) dips to the east or west, respectively (see Figure 2, Appendix A).

According to Laney and Bales (in progress), this unit has low intergranular permeability. Groundwater is likely present within the fractures of this unit; however, the fractures may not provide sufficient filtration of the lake water. A well not intercepting fractures may have low production due to the low, primary permeability of the Cemented Gravels.

3.1.3 Horse Spring Formation

The exposed Horse Spring Formation in the study area consisted of fine grained sands and silts. Principal exposures are at to slightly above lake water level along the west and southwest sides of the peninsula (Photograph P-2, Appendix B). Other exposures are present to the north and in the wash bottoms northeast of the peninsula. The Horse Spring Formation consisted of moderately cemented reddish-orange to tan sand and silt with altered volcanic clasts. This lithology is evident in the exposures on the west-central and southern portions of the peninsula near the present lake level. Beds dip as much as 30 degrees and strikes with various orientations were measured (Figure 2, Appendix A, Photograph P-2, Appendix B). Anticlinal and synclinal structures were inferred from the strike and dip measurements of the silty-sand outcrops along both the western shoreline and the southwestern end of the peninsula (see Figure 3, Appendix A).

The Horse Spring Formation, according to Laney and Bales (in progress) is highly mineralized, and would likely yield less than one gallon per minute of water to a well.

3.2 Structural Interpretation

Two cross sections A-A' and B-B' (Figure 3, Appendix A) illustrate the structural relationships of the described geologic units. Cross Section A-A' was located west to east across the southern portion of the field area. The Upper Unit appears flat-lying in this cross-section. Based on strike and dip measurements, a synclinal structure was identified in the Cemented Gravels. These dips may be due deposition on an inclined surface, (primary) not structural. The depth of the Cemented Gravels below the present level of Lake Mead is unknown. The limbs of the syncline dip about 30 degrees. The contact between the Upper Unit and the Cemented Gravels may represent erosion of the Upper Unit with later deposition of the Cemented Gravels. Based on the regional eastward dip, the maximum thickness of the Cemented Gravels should be at the southeastern end of the peninsula.

The Horse Spring Formation is inferred to underlie both units of the Older Alluvium. The eastward extension of the folded Horse Spring strata under the Cemented Gravels is unknown. Strike and dip measurements indicate that a shallow anticline is located in the Horse Spring Formation. The axis of the anticline trends northwest to southeast.

Cross Section B-B' is oriented north to south along the western portion of the peninsula. The Upper Unit unconformably overlies the Horse Spring Formation. A syncline with an axis trending northeast-southwest is inferred from strike and dip measurements.

4.0 GEOPHYSICAL SURVEY

Seismic and surface electrical resistivity surveys were originally considered to assist in delineating favorable strata for exploratory drilling. However, results of the Terracon geologic mapping indicated that the seismic survey would probably not provide useful information. Similar seismic velocities were expected in the fine grained, poorly to moderately cemented sediments of the Horse Spring strata and both units of the Older Alluvium. Further, the shallow depth of the Horse Spring-alluvial contact indicated that the Horse Spring Formation would not be a good reflector of seismic energy with the result that the interface of the shallow, permeable strata and the deeper, less permeable and mineralized Horse Spring strata would not be defined.

A surface resistivity survey, although originally considered, was not included in the proposed Scope of Work. Surface resistivity provides an average resistivity of earth materials with

depth. Coarse-grained, presumably more porous and permeable strata would likely have higher resistivity. Saturation of these materials would likely result in a resistivity decrease due to the conductivity of the fluids. Depth to water could be inferred. It was reasoned that there likely was insufficient resistivity contrast between the units identified to be cost effective. The depth to saturated material was, in all likelihood determined by the lake level. For all of these reasons, resistivity was not pursued as a sufficiently diagnostic technique.

5.0 INTERVIEW WITH ROBERT LANEY

Mr. Robert Laney, formerly with the U.S. Geological Survey and a principal investigator on prior geologic and hydrogeologic investigations in the Lake Mead area, was interviewed for information regarding the potential well sites and for his opinion regarding the geologic interpretation of the study area as presented herein. Mr. Laney provided the following:

- 1) Concurrence with placement of the exploration well sites (Figure 2, Appendix A). The sites appeared to be sufficiently inland to provide microorganism filtration of the lake water, without adding undue TDS concentrations to the water. However, the sites are exploratory only and may not produce usable water quality or flow rates.
- 2) Agreement that geophysical surveys would likely not provide any usable information based on the nature of the sediments in the field area.
- 3) Opinion that juxtaposition of the Lower Unit of the Older Alluvium against the Upper Unit may be the result of either depositional history or faulting.
- 4) Opinion that the fine grained material underlying the Older Alluvium is the Horse Spring Formation.

6.0 PRIOR EXPLORATION WELL

Laney and Bales (in progress) reported on an exploratory water supply well (D-21-65)9dbb, drilled at Callville Bay Marina in 1967. The well was reportedly installed in 178 feet of Older Alluvium and 22 feet of fine-grained deposits of the Horse Spring Formation. A water sample from the well contained 3,700 milligrams per liter (mg/L) of dissolved solids, 1200 mg/L of sulfate and 1,190 mg/L of chloride. The well yield was low and the water quality was well below the drinking water standards in terms of TDS, sulfate, and chloride.

7.0 FINDINGS AND CONCLUSIONS

- Groundwater in the area of investigation is primarily a result of lateral inflow of lake water.
- Lake water reportedly saturates rocks up to one-half mile inland. However, the longer residence time of the water in the gypsiferous rocks and their lower permeability increases the concentrations of total dissolved solids and individual parameters (e.g. sulfate, chloride). Preferred locations for exploratory wells are close to the shore where lake water would be stored in the aquifer materials for a short period of time yet still provide the necessary filtration to remove microorganisms.
- The western portion and the southwestern end of the peninsula are most likely underlain by the fine-grained Tertiary Horse Spring Formation which cropped out at the lake water level (Winter 1994-1995). This formation is expected to yield approximately one gallon per minute of water to wells. The overlying sediments of the Upper Unit, in the western half of the peninsula are unsaturated. Therefore, exploration should focus on other areas of the peninsula where saturated strata overlie the Horse Spring Formation.
- The northeast and northwest ends of the peninsula are surrounded by lake water with minimal circulation as compared to the water adjacent to the southern end of the peninsula. Stagnant water would be expected to have a generally higher microorganism population. Further, the saturated sediments adjacent to the northerly portion of the peninsula appear to be the low permeability Horse Spring Formation. Therefore, the northern portions of the peninsula are not suitable drilling locations because of aquifer material and water quality reasons.
- Based on the geologic reconnaissance conditions, the southeastern portion of the peninsula provides the best opportunity to site an exploration well. Two exploration well locations were selected (Figure 2, Appendix A).
- The southeastern end of the peninsula has the thickest section of saturated gravel deposits. Based on the mapped locations and overall eastward dip of the

peninsula strata, the greatest thickness of saturated gravels is expected in this part of the peninsula. Although the gravels have an inferred low permeability, interconnected fractures within the unit should provide a connection between the lake water and the proposed exploration well. Water sampling results for the test well(s) should indicate whether filtration will be sufficient to remove the microorganisms. Aquifer testing will indicate well yield.

- Seismic surveys would probably not provide useful information based on the lithologic units present and the inferred depth to groundwater. The effort and expense would be better suited to construction of an additional exploration well to increase the probability of favorable well yield and water quality.
- Native American artifacts along the western ridge of the peninsula require archaeologic clearance prior to commencement of drilling or testing. Subsurface conditions indicate a low permeability aquifer. Further, road construction in this area would be costly and cause aesthetic impairment. For these reasons, this portion of the peninsula is generally unsuitable for a test well site.

8.0 RECOMMENDATIONS

- Drill an exploratory well at the southeastern end of the peninsula in the Cemented Gravels of the Older Alluvium (Figure 2, Appendix A). If fine grained sediments of the Horse Spring Formation are encountered, drilling should be terminated.
- In lieu of seismic surveys, install a second test well on the southeastern portion of the peninsula.

9.0 CLOSURE

This non-intrusive assessment relied upon readily accessible information and was not designed to provide extensive data accumulation or detailed inferences as to the condition of subsurface soils or groundwater. No chemical testing of the soil or water was performed on this property. The scope of work performed will not provide sufficient information to eliminate the possibility of low yield aquifer conditions or water of unacceptable quality. In general,

significantly greater levels of effort, including intrusive sampling, test well construction, and analytical testing, would be required to approach this type of result.

This report, prepared for the exclusive use of the National Park Service for specific application to the project as discussed herein, has been prepared in accordance with generally accepted hydrogeology practices within the constraints of the client's directives. No warranties, either expressed or implied, are made or intended.

TERRACON CONSULTANTS WESTERN, INC.



Delane P. Fitzpatrick, C.E.M. 1365
Project Hydrogeologist



Robert F. Kaufmann, C.E.G., C.E.M. 1016
Vice President

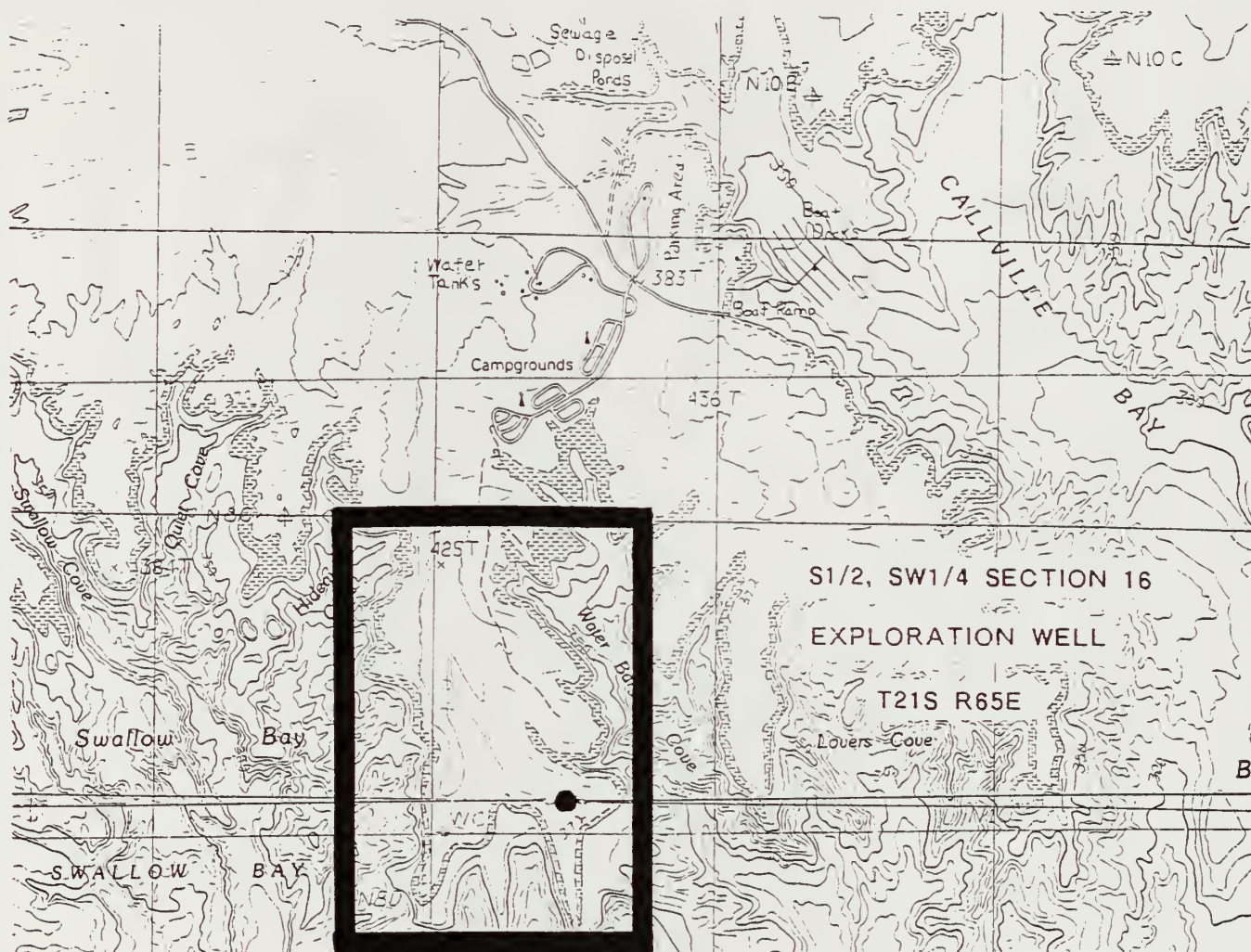
DPF/RFK/cmc

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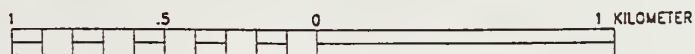
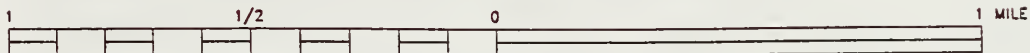
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- 1979b, Geohydrologic reconnaissance of Lake Mead National Recreation Area-Hoover Dam to Temple Bar, Arizona: U.S. Geological Survey Open-File Report 79-689, 42 p.
 - 1979c, Summary appraisal of the potential water resources in and near Tract 01-113, Lake Mead National Recreation area, Nevada: U.S. Geological Survey Open-File Report 79-698, 6 p.

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Laney, R.L., and Bales, J.T., (in progress), Geohydrologic reconnaissance of Lake Mead National Recreation Area-Las Vegas Wash To Virgin River, Nevada: U.S. Geological Survey Water Resources Investigations Report 93- 32 p.



Contour interval 20 meters, underwater cantaur interval 10 meters.



U.S.G.S. 7 1/2 Quadrangle Maps "Hoover Dam, Nev.-Ariz." and "Callville Bay, Nev.-Ariz."

CLIENT:

NATIONAL PARK SERVICE

PROJECT:

GEOLOGIC RECONNAISSANCE

Terracon

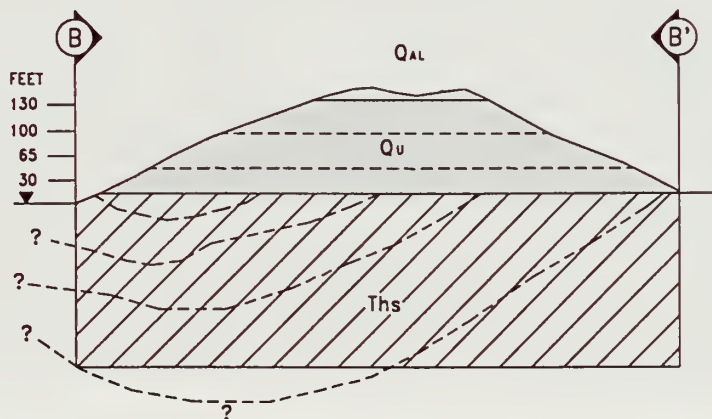
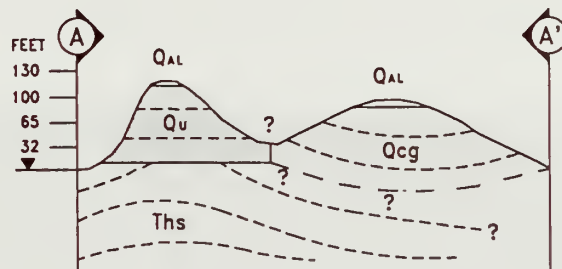
LOCATION MAP

PROJECT NO.:

64947206

FIGURE:

1



LITHOLOGIC UNITS:

QAL	- QUATERNARY ALLUVIUM
Qu	- QUATERNARY-TERTIARY UPPER UNIT OLDER ALLUVIUM
Qcg	- CEMENTED GRAVELS OLDER ALLUVIUM
Ths	- TERTIARY HORSE SPRING FORMATION

VERTICAL SCALE: 5 X EXAGGERATION

HORIZONTAL SCALE: 1 INCH = 1000 FEET

- - APPROXIMATE LOCATION OF CONTACT
DASHED WHERE INFERRED
- - BEDDING PLANES

CLIENT: NATIONAL PARK SERVICE

PROJECT: GEOLOGIC RECONNAISSANCE

Terracon

CROSS SECTIONS

PROJECT NO.: 64947206

FIGURE:

3



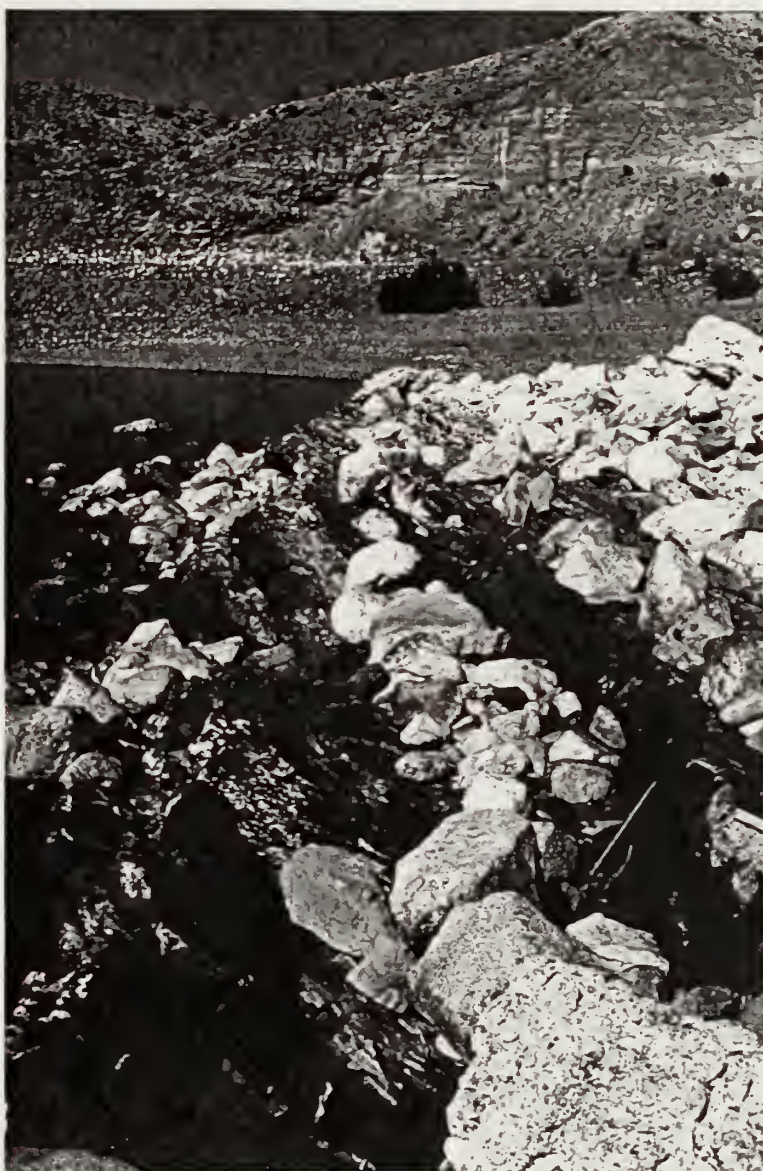
Photograph P-1

Photo view to the west. Cemented Gravels (Qcg) are shown in the foreground.

The tan Upper Unit of the Older Alluvium (Qu) is shown in the background. A cemented alluvial cap (Qal) overlies the upper unit.

Photograph location shown on Figure 2.

CLIENT:	NATIONAL PARK SERVICE	Terracon	PHOTOGRAPHIC RECORD	
PROJECT:	GEOLOGIC RECONNAISSANCE		PROJECT NO.:	APPENDIX:
			64947206	B-1



Photograph P-2

Photo view to the north.
East dipping Horse Spring Formation in the foreground overlain by light
colored colluvial materials from the Upper Unit of the Older Alluvium.
Photograph location shown on Figure 2.

CLIENT:	NATIONAL PARK SERVICE	Terracon		PHOTOGRAPHIC RECORD	
PROJECT:	GEOLOGIC RECONNAISSANCE			PROJECT NO.:	APPENDIX:
		64947206	B-2		

EXPLORATION WELL BORING LOG 1

CLIENT: National Park Service		PROJECT: Groundwater Exploration	
WELL LOCATION: See Site Diagram	ELEVATION (ft.): Not Measured	SITE: Calville Bay	

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	FORMATION	
	TOP OF KELLY BUSHING: 67 inches TYPE OF CASING: steel BOREHOLE DIAMETER: 9 7/8 inches WELL DIAMETER: 6"				
	Cemented alluvial silts and fine gravels			Quaternary - Tertiary Older Alluvium	Grout
	5.0				
	GRAVEL -fine to coarse, poorly graded, carbonates and minor red sandstone, cemented, subrounded to subangular				
	15.0				
	SILTY GRAVEL -fine gravels, medium sand with silts, cemented, subrounded to angular, carbonate gravel, well graded			Quaternary - Tertiary Older Alluvium	Grout
	40.0				
Continued Next Page					

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

*Sample Types: ppm = Parts Per Million
R = Ring X = Not Retrieved

NOTES: Water level measured at 93 ft.		DATE DRILLED: 4-7-95	PAGE NUMBER: Page 1 of 5
		PROJECT NO.: 64947206	PLATE: A-1

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER WITH TIME OR AT OTHER LOCATIONS.

EXPLORATION WELL BORING LOG 1

CLIENT: National Park Service		PROJECT: Groundwater Exploration	
WELL LOCATION: See Site Diagram	ELEVATION (ft.): Not Measured	SITE: Calville Bay	

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	FORMATION	
	SILTY GRAVEL -w/fine gravels, medium sand with silt, cemented, subangular to subrounded, well graded carbonates predominantly		45		Centralizer
			50		Grout
			55		
			60		
			65		Gravel Pack
			70		
			75		
			80		
	75.0				
	SILTY GRAVEL -w/sand, increase sand relative to gravels, subangular to subrounded, well graded cemented, carbonate gravel predominantly				
	80.0				
	Continued Next Page				

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

*Sample Types: ppm = Parts Per Million
R = Ring X = Not Retrieved

NOTES:
Water level measured at 93 ft.

Terracon

DATE DRILLED:
4-7-95

PAGE NUMBER:
Page 2 of 5

PROJECT NO.:
64947206

PLATE:
A-2

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER WITH TIME OR AT OTHER LOCATIONS.

EXPLORATION WELL BORING LOG 1

CLIENT:

National Park Service

PROJECT:

Groundwater Exploration

WELL LOCATION:

See Site Diagram

ELEVATION (ft.):

Not Measured

SITE:

Calville Bay

GRAPHIC LOG

DESCRIPTION

WELL
DETAIL

DEPTH (FT.)

FORMATION

SILTY GRAVEL -w/sand, increase sand
relative to gravels, subangular to
subrounded, moderately graded
cemented, primarily carbonates

90.0

SILTY GRAVEL -w/sand, medium sand and
fine gravels, subangular and subrounded,
well graded cemented, primarily
carbonates

95.0

SILTY CLAY -w/sand, medium sand,
reddish brown

100.0

GRAVEL -w/sand, fine subangular to
subrounded carbonate gravels,
moderately graded, cemented, gray

fine gravel and sand, subangular to
subrounded volcanics

120.0

85

90

95

100

105

110

115

120

Blank
Casing

Centralizer

Continued Next Page

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES
BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

*Sample Types: ppm = Parts Per Million
R = Ring X = Not Retrieved

NOTES:

Water level measured at 93 ft.

Terracon

DATE DRILLED:

4-7-95

PAGE NUMBER:

Page 3 of 5

PROJECT NO.:

64947206









PLATE:

A-3

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER WITH TIME OR AT OTHER LOCATIONS.

EXPLORATION WELL BORING LOG 1

CLIENT: National Park Service		PROJECT: Groundwater Exploration	
WELL LOCATION: See Site Diagram	ELEVATION (ft.): Not Measured	SITE: Calville Bay	

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	FORMATION			
	SILTY SAND -fine to coarse, subrounded to subangular, well graded volcanics and carbonates		125	Tertiary - Horse Spring Formation	Screen		
127.0			130				
	SILTY SAND -w/gravel, fine sand and gravels, anugular to subrounded, weakly cemented, red, silt-coated grains		135				
140.0			140				
	SAND -fine to coarse, moderately graded, angular to subangular, dark gray		145				
145.0			150				
	SILTY SAND -fine, poorly graded, brown		155				
160.0			160				
Continued Next Page							

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

*Sample Types: ppm = Parts Per Million
R = Ring X = Not Retrieved

NOTES:
Water level measured at 93 ft.

Terracon

DATE DRILLED:
4-7-95

PAGE NUMBER:
Page 4 of 5















PROJECT NO.:
64947206

PLATE:
A-4

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER WITH TIME OR AT OTHER LOCATIONS.

EXPLORATION WELL BORING LOG 1

CLIENT: National Park Service		PROJECT: Groundwater Exploration	
WELL LOCATION: See Site Diagram	ELEVATION (ft.): Not Measured	SITE: Calville Bay	

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	FORMATION	
	SILTY SAND -fine to medium, moderately graded, angular to subangular, volcanics, gray		165.0		Centralizer
	SILT -poorly cemented, red brown		165 170 175		Blank Casing
	SAND -fine to coarse, poorly to moderately graded, subrounded to angular, dark gray, volcanics		180.0		Screen
	SAND -w/medium sand, angular to subrounded, altered volcanics		183.0		
	SANDS AND CLAYS -fine gravels, red		185.0		
	SILT -w/clay, red		185		Blank
	SAND -fine to very fine, brown		190.0 195		Centralizer
	End Cap - Welded Steel Plate		200.0		
	Bottom at 200 feet		200		

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

*Sample Types: ppm = Parts Per Million
R = Ring X = Not Retrieved

NOTES:
Water level measured at 93 ft.

Terracon

DATE DRILLED:
4-7-95

PAGE NUMBER:
Page 5 of 5

PROJECT NO.:
64947206

PLATE:
A-5

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER WITH TIME OR AT OTHER LOCATIONS.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests^a

Criterion for Assigning Group Symbols and Group Names Using Laboratory Tests ^A				Soil Classification		
				Group Symbol	Group Name ^B	
Coarse-Grained Soils, more than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines ^C	$Cu > 4$ and $1 < Cc < 3^E$	GW	Well-graded gravel ^F	
			$Cu < 4$ and/or $1 > Cc > 3^E$	GP	Poorly graded gravel ^F	
		Gravels with Fines More than 12% fines ^C	Fines classify as ML or MH	GM	Silty gravel ^{F, G, H}	
			Fines classify as CL or CH	GC	Clayey gravel ^{F, G, H}	
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean sands Less than 5% fines ^E	$Cu > 6$ and $1 < Cc < 3^E$	SW	Well-graded sand ^I	
			$Cu < 6$ and/or $1 > Cc > 3^E$	SP	Poorly graded sand ^I	
		Sands with Fines More than 12% fines ^C	Fines classify as ML or MH	SM	Silty sand ^{G, H, I}	
			Fines classify as CL or CH	SC	Clayey sand ^{G, H, I}	
	Fine-Grained Soils 50% or more passes the No. 200 sieve	Silt and Clays Liquid limit less than 50	inorganic	PI > 7 & plots on or above "A" line ^J	CL	Lean clay ^{K, L, M}
				PI < 4 or plots below "A" line ^J	ML	Silt ^{K, L, M}
			organic	Liquid limit - oven dried < 0.75	OL	Organic clay ^{K, L, M, N}
				Liquid limit - not dried < 0.75		Organic silt ^{K, L, M, O}
Silt and Clays Liquid limit 50 or more		inorganic	PI plots on or above "A" line	CH	Fat clay ^{K, L, M}	
			PI plots below "A" line	MH	Elastic silt ^{K, L, M}	
		organic	Liquid limit - oven dried < 0.75	OL	Organic clay ^{K, L, M, P}	
			Liquid limit - not dried < 0.75		Organic silt ^{K, L, M, O}	
Highly organic soils				PT	Peat	
Primarily organic matter, dark in color, and organic odor						

^aBased on the material passing the 3-in. (75-mm) sieve.

^bIf field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^cGravels with 5 to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

^dSands with 5 to 12% fines require dual symbols:

SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

$$^e Cu = D_{60} / D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

^fIf soil contains $\geq 15\%$ sand, add "with sand" to group name.

^gIf fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

^hIf fines are organic, add "with organic fines" to group name.

ⁱIf soil contains $\geq 15\%$ gravel, add "with gravel" to group name.

^jIf Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

^kIf soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant

^lIf soil contains $\geq 30\%$ plus, No. 200 predominantly sand, add "sandy" to group name.

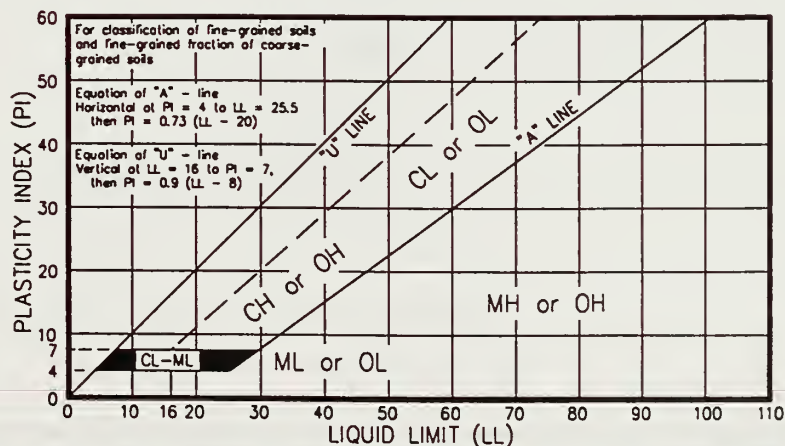
^mIf soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

ⁿ $PI > 4$ and plots on or above "A" line.

^o $PI < 4$ or plots below "A" line.

^p PI plots on or above "A" line.

^q PI plots below "A" line.



CLIENT:

NATIONAL PARK SERVICE

PROJECT:

GROUNDWATER EXPLORATION

Terracon

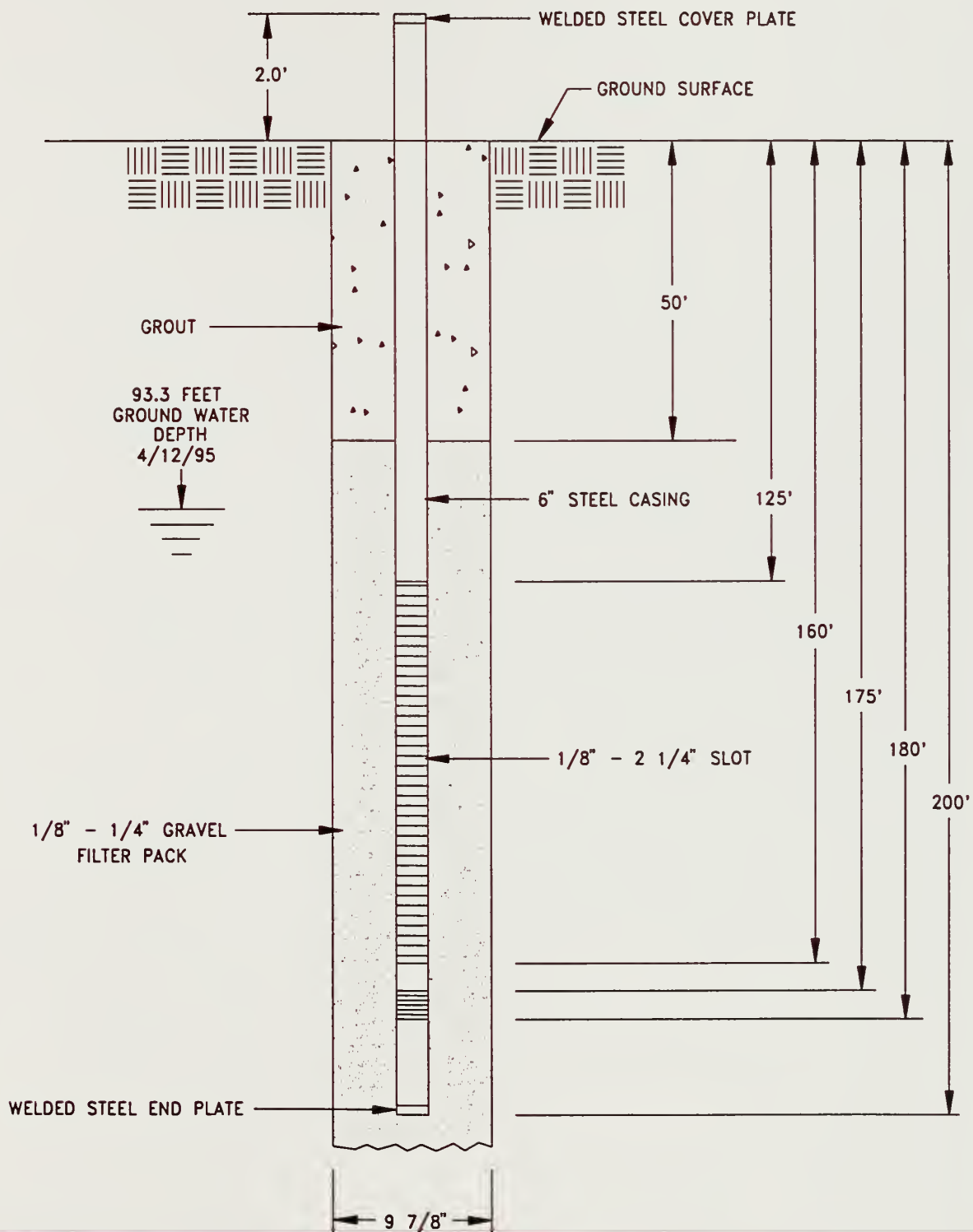
UNIFIED SOIL
CLASSIFICATION SYSTEM

PROJECT NO.:

64947206

PLATE:

B



CLIENT: NATIONAL PARK SERVICE

PROJECT: GROUNDWATER EXPLORATION

Terracon

**EXPLORATION WELL
CONSTRUCTION DIAGRAM**

PROJECT NO.: 64947206

PLATE:

C

BOB MILLER
Governor

STATE OF NEVADA

R. MICHAEL TURNIPSEED, P.E.
State Engineer

PETER G. MORROS, P.E.
Director



G. W. "BILL" QUINN, P.E.
Chief Engineer

SOUTHERN NEVADA BRANCH OFFICE
(702) 486-7052

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES
SOUTHERN NEVADA BRANCH OFFICE
Mailroom Complex
Las Vegas, Nevada 89158

April 24, 1995

WAIVER: W-2064

Mr. Steven N. Spearman
National Park Service
601 Nevada Highway
Boulder City, NV 89005

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL

of pages 1

To	DELANE FITZPATRICK	From	S. SPEARMAN
Dept.	ERRACON	Phone #	367-3711
Fax #	367-1471	Fax #	

NSN 7540-01-317-7308 5099-101 GENERAL SERVICES ADMINISTRATION

Dear Mr. Spearman

Under the provisions of NRS 534.050(2), authorization is hereby granted this date to drill one (1) exploration well located within the SE 1/4 of the SW 1/4 of Section 16, T.21S., R.65E. M.D.B.&M., in Clark County, Nevada, as described in your request of April 17, 1995. This office also waives NAC 534.390(1).

The intent to drill card and log, when filed shall bear Waiver No. W-2064, name, and license number of the driller performing the work. If the data indicate that the well cannot be used, the well must be plugged per NAC 534.420 by a well driller licensed in Nevada.

This waiver is written with the understanding that legal authority to acquire and use water from the Colorado River System stems from administration of entitlements of Colorado River water by the Bureau of Reclamation, and that use of infiltrated water from Lake Mead is within the intent of your Federal reserved water rights.

Sincerely,

A handwritten signature in cursive script that reads "Richard A. Moles".

Richard A. Moles, P.E.
Hydraulic Engineer

cc: Carson City Office
G.L. Edwards, C.R.C.

AQUIFER TEST FIELD DATA SHEET

DESIGNATION: _____ DATE: 4/12/95
 WELL NUMBER: WW-1 OBSERVERS: _____
 GROUND SURFACE ELEVATION: _____

BEGINNING: 100 GPM METHOD _____
 END: _____ GPM METHOD _____
 STOP WATCH & Flow Meter

PERFORATED INTERVALS: Perforations start at 125.0

WATER LEVEL MEASUREMENT METHOD(S)
 SOUNDER AIRLINE AIRLINE 146.4 LENGTH FT
 MEAS. PT. (MP) IS _____ FT. ABOVE LSD
 SWL _____ FT BELOW MP
 SWL = AIRLINE SETTING, FT - (PSI X 2.31)
 = 146.4 FT - (2.3 PSI X 2.31)
 = 93.3 FEET

PUMP SETTING 150.0 FEET BELOW LSD:
 _____ FEET BELOW MP

PUMP STARTED: DATE 4/12/95 TIME 13:05
 PUMP OFF: DATE 4/13/95 TIME 13:05

FLOW MEASUREMENT METHOD(S)
☒ FLOW METER FLUME _____
☐ ORIFICE PLATE OTHER (DESCRIBE) _____
Flow Meter start - 30000 at 13105
Flow Meter stopped at 68600
at approx 20:40

AQUIFER TEST DURATION 40 minutes HRS DRAWDOWN
6 minutes HRS RECOVERY

Date	Time	t Time since pumping began, minutes	t' Time since pumping stopped, minutes	Ratio t/t'	Airline reading, psi	PWL = Airline Setting - (psi x 2.31)	s Drawdown, ft (SWL - PWL)	Q Discharge gpm	Q/s Specific Capacity	Remarks (computations, temperature, sand content, sp. conductivity)
<u>4/12/95</u>	<u>13:05</u>	<u>0</u>			<u>14.0</u>	<u>114.1</u>	<u>20.7</u>	<u>100</u>	<u>4.83</u>	
	<u>13:07</u>	<u>2</u>			<u>13.0</u>	<u>116.4</u>	<u>23.1</u>	<u>100</u>	<u>4.33</u>	
	<u>13:09</u>	<u>4</u>			<u>12.0</u>	<u>118.7</u>	<u>25.4</u>	<u>100</u>	<u>3.94</u>	
	<u>13:11</u>	<u>6</u>			<u>12.0</u>	<u>118.7</u>	<u>25.4</u>	<u>100</u>	<u>3.94</u>	
	<u>13:13</u>	<u>8</u>			<u>12.0</u>	<u>118.7</u>	<u>25.4</u>	<u>100</u>	<u>3.94</u>	
	<u>13:15</u>	<u>10</u>			<u>12.0</u>	<u>118.7</u>	<u>25.4</u>	<u>100</u>	<u>3.94</u>	
	<u>13:20</u>	<u>15</u>			<u>12.0</u>	<u>118.7</u>	<u>25.4</u>	<u>100</u>	<u>3.94</u>	<u>26.0 °C, 0.93 cond</u>
<u>✓</u>	<u>13:25</u>	<u>20</u>			<u>12.0</u>	<u>118.7</u>	<u>25.4</u>	<u>100</u>	<u>3.94</u>	

Date	Time	t Time since pumping began, minutes	t' Time since pumping stopped, minutes	Ratio t/t'	Airline reading, psi	PWL = Airline Setting - (psi x 2.31)	s Drawdown, ft (SWL - PWL)	Q Discharge gpm	Q/s Specific Capacity	Remarks (computations, temperature, sand content, sp. conductivity)
4/12/95	13:30	25			11.8	119.1	25.8	100	3.88	0 PPM sand H ₂ O oxygenated
	13:35	30			11.5	119.8	26.5	100	3.77	100 GPM
	13:45	40			11.3	120.3	27.0	100	3.70	25.4°C, 1.43 cond, PH 8.45, 20 grains sand per 1000 mL
	13:55	50			11.0	121.0	27.7	100	3.61	
	14:05	60			11.0	121.0	27.7	100	3.61	25.5°C, 1.42 cond, PH 8.80, 20 grains sand per 1000 mL
	14:20	75			11.0	121.0	27.7	100	3.61	
	14:35	90			11.0	121.0	27.7	95	3.42	24.0°C, 1.42 cond, PH 8.89, 95 GPM
	14:50	105			11.0	121.0	27.7	95	3.42	25.7°C, 1.42 cond, PH 8.81, 20 grains sand per 1000 mL
	15:05	120			11.3	120.3	27.0	93	3.44	25.6°C, 1.42 cond, PH 8.95, 93 GPM
	15:20	135			11.5	119.3	26.6	90	3.46	25.8°C, 1.42 cond, PH 8.95, 90 GPM
	15:35	150			11.5	119.3	26.6	90	3.46	25.7°C, 1.42 cond, PH 8.96, 20 grains sand per 1000 mL
	15:50	165			11.8	119.1	25.8	88	3.41	25.7°C, 1.42 cond, PH 8.94, 88 GPM
	16:05	180			11.8	119.1	25.8	88	3.41	25.6°C, 1.42 cond, PH 8.89
	16:20	195			12.0	118.7	25.4	86	3.39	25.6°C, 1.42 cond, PH 8.90
	16:35	210			12.3	118.0	24.7	84	3.40	Approx 20 grains sand per 1000 mL
	16:50	225			12.2	118.0	24.7	82	3.32	82 GPM
	17:05	240			12.5	117.5	24.2	82	3.39	25.8°C, 1.42 cond, 6.97 PH,
	17:20	255			12.8	116.8	23.5	82	3.49	82 GPM
	17:35	270			12.8	116.8	23.5	82	3.49	
	17:50	285			13.0	116.4	23.1	80	3.46	50 GPM
	18:05	300			13.2	115.9	22.6	80	3.54	25.3°C, 1.44 cond, 6.96 PH, 80 GPM
	18:20	315			13.5	115.2	21.9	78	3.56	25.3°C, 1.45 cond, 6.96 PH, 78 GPM

Started filter at 14:15 PM on 4/12/95

Lake readings 18.8°C

1.08 cond

4.06 PH

17:30

Cell #
277-7951
Oxalates Cell #

called Dale Briner at 8:15pm

Date	Time	t Time since pumping began, minutes	t' Time since pumping stopped, minutes	Ratio t/t'	Airline reading, psi	PWL = Airline Setting - (psi x 2.31)	s Drawdown, ft (SWL - PWL)	Q Discharge gpm	Q/s Specific Capacity	Remarks (computations, temperature, sand content, sp. conductivity)
4/12/91	18:35	330			13.5	115.2	21.9	78	3.56'	Approx 20 grains sand per 1000 mL
	18:50	345			13.5	115.2	21.9	76	3.47	25.1°C, 1.44 cond, 6.96 pH, 76 gpm
	19:05	360			13.5	115.2	21.9	74	3.38	24.1°C, 1.44 cond, 6.96 pH, 74 gpm
	19:20	375			13.8	114.5	21.2	74	3.49	25.0°C, 1.44 cond, 6.96 pH, 74 gpm
	19:35	390			14.0	114.1	20.8	72	3.46	24.8°C, 1.44 cond, 6.96 pH, 72 gpm
	19:50	405			14.0	114.1	20.8	70	3.37	24.7°C, 1.45 cond, 6.96 pH, 70 gpm
	20:05	420			14.6	114.1	20.8	70	3.37	
	20:20	435			14.3	113.4	20.1	70	3.48	24.4°C, 1.44 cond, 6.96 pH, 70 gpm
	20:35	450			14.5	112.9	19.6			Flow meter stuck at 6800 gpm
	20:50	465			14.8	112.2	18.9			
	21:05	480			14.8	112.2	18.9			
	21:20	495			14.8	112.2	18.9			
	21:30	510			15.0	111.7	18.4			
	21:45	525			15.2	111.2	17.9			
	22:00	540			15.5	110.5	17.2			
	22:15	555			15.8	109.9	16.6			
	22:30	570			16.0	109.4	16.1			
	22:45	585			16.0	109.4	16.1			
	23:00	600			16.2	108.9	15.6			
	23:15	615			16.2	108.9	15.6			
	23:30	630			16.2	108.9	15.6			
	23:45	645			16.4	108.5	15.2			
	24:00	660			16.4	108.5	15.2			
	24:15	675			16.4	108.5	15.2			

when I release Scott fill all PEL containers
and Filter and water

- Flow Meter Stuck at 6800 at approx 20:40
4.50 seconds to fill a 5 gallon Bucket

Sampled Filter at 09:00 am 4:13:95 End Flow Meter Reading 3396.3

Sampled NEL Jars at 09:15 am 4:13:95

Checked water level with Solinst at 12:00 - 107.3'

**NEVADA ENVIRONMENTAL
LABORATORY**

Las Vegas Division
4208 Arcata Way, Suite A • Las Vegas, NV 89030
(702) 657-1010 • Fax: (702) 657-1577
1-800-368-5221

CLIENT: Terracon
3711 Regulus Drive
Las Vegas, NV 89102

ATTN: Delane Fitzpatrick

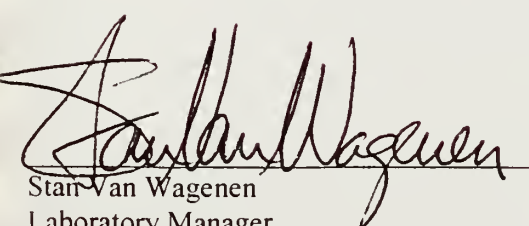
PROJECT NAME: Callville Bay
PROJECT NUMBER: 64947206

NEL ID: L9504065

Attached are the analytical results for samples in support of the above referenced project.

Samples submitted for this project on 04/13/95 were received in good condition and under chain of custody. Unless otherwise noted, no anomalies were associated with this project.

Should you have any questions or comments, please feel free to contact our Client Services department
(702) 657-1010.


Stan Van Wagenen
Laboratory Manager

4/24/95
Date

NEVADA ENVIRONMENTAL LABORATORY

CLIENT: Terracon
PROJECT NAME: Callville Bay
PROJECT NUMBER: 64947206

METHOD: INORGANIC NON-METALS

SAMPLE MATRIX: WATER

CLIENT ID: NPS-Well-1
NEL ID: L9504065-01

DATE SAMPLED: 04/13/95

<u>PARAMETER</u>	<u>RESULTS</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>EPA METHOD</u>	<u>ANALYZED</u>
pH	8.01	NA	pH units	150.1	04/13/95
Nitrate, as N	9.9	0.01	mg/L-N	353.3	04/13/95
Total Dissolved Solids	870	5.0	mg/L	160.1	04/19/95
Chloride	120	0.2	mg/L	325.3	04/19/95
Fluoride	3.1	0.1	mg/L	340.2	04/19/95
Sulfate	460	0.01	mg/L	375.4	04/20/95
MBAS	ND	0.2	mg/L	SM5540	04/14/95
Turbidity	5.82	0	NTU	180.1	04/13/95
Color*	1	1	CU	2120 C	04/13/95
Total Coliform/100 mL MPN*	1.1			9221 B	04/13/95

* Sample subcontracted to EFFEX Analytical Services - Las Vegas, NV

NEVADA ENVIRONMENTAL LABORATORY

CLIENT: Terracon
PROJECT NAME: Callville Bay
PROJECT NUMBER: 64947206

ANALYST: JY

METHOD: TOTAL METALS

SAMPLE MATRIX: DRINKING WATER

CLIENT ID: NPS-Well-1
DATE SAMPLED: 04/13/95
NEL ID: L9504065-01

DIGESTED: 04/27/95
ANALYZED: 04/27, 05/05/95

<u>PARAMETER</u>	<u>EPA METHOD</u>	<u>RESULT</u> <u>mg/L</u>	<u>REPORTING</u> <u>LIMIT</u>
Arsenic	206.2	0.0064	0.002 mg/L
Barium	4.1.4/200.7	0.12	0.005 mg/L
Cadmium	4.1.4/200.7	ND	0.010 mg/L
Chromium	4.1.4/200.7	ND	0.010 mg/L
Copper	4.1.4/200.7	0.020	0.005 mg/L
Iron	4.1.4/200.7	4.0	0.020 mg/L
Lead	239.2	ND	0.005 mg/L
Manganese	4.1.4/200.7	0.16	0.005 mg/L
Mercury	245.1	ND	0.002 mg/L
Selenium	270.2	0.0079	0.004 mg/L
Silver	4.1.4/200.7	ND	0.020 mg/L
Zinc	4.1.4/200.7	0.22	0.010 mg/L

CLIENT ID: NA
DATE SAMPLED: NA
NEL ID: Method Blank

DIGESTED: 04/27/95
ANALYZED: 04/27,05/05/95

<u>PARAMETER</u>	<u>EPA METHOD</u>	<u>RESULT</u> <u>mg/L</u>	<u>REPORTING</u> <u>LIMIT</u>
Arsenic	206.2	ND	0.002 mg/L
Barium	4.1.4/200.7	ND	0.005 mg/L
Cadmium	4.1.4/200.7	ND	0.010 mg/L
Chromium	4.1.4/200.7	ND	0.010 mg/L
Copper	4.1.4/200.7	ND	0.005 mg/L
Iron	4.1.4/200.7	ND	0.020 mg/L
Lead	239.2	ND	0.005 mg/L
Manganese	4.1.4/200.7	ND	0.005 mg/L
Mercury	245.1	ND	0.002 mg/L
Selenium	270.2	ND	0.002 mg/L
Silver	4.1.4/200.7	ND	0.020 mg/L
Zinc	4.1.4/200.7	ND	0.010 mg/L

EPA Method 4.1.4, December 1982
EPA Method 200.7, December 1982
EPA Method 206.2, December 1982
EPA Method 239.2, December 1982
EPA Method 270.2, December 1982

ND - Not Detected

Las Vegas Division • 4208 Arcata Way, Ste. A • Las Vegas, NV 89030
(702) 657-1010 • FAX: (702) 657-1577 • 1-800-368-5221

Terracon Consultants Delane Fitzpatrick
Company: 3711 REGULUS DR. Attn: LAS VEGAS NV 89102

Address:

702-367-3711 367 1471

Phone No.:

Fax No.:

4-21-95

Billing Address:

Expected Due Date:

Requested Turnaround: ☒ 5 Day (Normal) 48 Hr. 24 Hr. Other

Sample Date/Time

Sample ID

N.E.L. Identification

4-13-95 NPS-WE11-1 19504065-01

Project Name:

CALVILLE BAY

Project No.:

64947206

P.O. No.:

Sampled By:

Stefan Hoffman

of Containers 8
Matrix (Box #1) F
Preservative (Box #2) 7
Expected Concentration (Box #3) 7

USE EPA
SDW
Primary + Secondary Standards
Inorganic
General Inorganic
Microbiology
Bacteriology

PH (for lab use only)

Remarks

This report is applicable only to the sample received by the laboratory. The liability of the laboratory is limited to the amount paid for this report. This report is for the exclusive use of the client to whom it is addressed and upon the condition that the client assumes all liability for the further distribution of the report or its contents

Box #1

DW - Drinking Water
WW - Waste Water
RW - RCRA Water
OL - Oil
SG - Sludge

SO - Soil
SD - Solid
AO - Aqueous
A - Air

Box #2

A. HCl
B. HNO₃
C. H₂SO₄
D. NaOH

E. Ice Only
F. Other ORGANIC
G. Not Preserved

Box #3

H - High
M - Medium
L - Low
U - Unknown

Relinquished by (Print)

(Signature)

Date/Time

Received by (Print)

(Signature)

Date/Time

1 DELANE FITZPATRICK Delane Fitzpatrick 4-13-95 10:30

Wesley J. S. 1471 Wesley J. S. 4/13/95 11:45

Table 1. Summary of Water Sample Analytical Results			
EPA Method	Nevada Environmental Laboratory Date Sampled: April 13, 1995		Maximum Contaminant Levels (MCLs) *
150.1	pH	8.01	6.5-8.5
353.3	Nitrate as N	9.9 mg/l-N	10 mg/l-N
150.1	Total Dissolved Solids	870 mg/l	500 mg/l
325.3	Chloride	870 mg/l	125 mg/l
340.2	Fluoride	3.1 mg/l	4.0 mg/l
375.4	Sulfate	460 mg/l	250 mg/l
SM5540	MDAS	ND	0.5 mg/l
180.1	Turbidity	5.82 NTU	1/5 NTU
2120C	Color	1	15 Color Units
9221B	Total Coliform/100 ml MPN	1.1	Coliform Present
206.2	Arsenic	0.0064 mg/l	0.05 mg/l
4.1.4/200.7	Barium	0.12 mg/l	1 mg/l
4.1.4/200.7	Cadmium	ND mg/l	0.050 mg/l
4.1.4/200.7	Chromium	ND mg/l	0.050 mg/l
4.1.4/200.7	Copper	0.020 mg/l	1 mg/l
4.1.4/200.7	Iron	4.0 mg/l	0.3 mg/l
239.2	Lead	ND mg/l	0.050 mg/l
4.1.4/200.7	Manganese	0.16 mg/l	0.05 mg/l
245.1	Mercury	ND mg/l	0.002 mg/l
270.2	Selenium	0.0079 mg/l	0.05 mg/l
4.1.4/200.7	Silver	ND mg/l	0.050 mg/l
4.1.4/200.7	Zinc	0.22 mg/l	5 mg/l

N = Nitrogen

mg/l = Milligrams per liter

* = MCLs refer to the primary and secondary drinking water standards for the purpose of this report.

Table 1. Summary of Water Sample Analytical Results (continued)

Analytical Method	CH Diagnostic and Consulting Services, Inc. Date Sampled: April 12 and 13, 1995
EPA Consensus Method for Determining Groundwaters under the direct influence of surface water using MPA Analysis	<p>Amorphous Debris: Silica, inorganic precipitate & sand, 1-100μM diameter</p> <p>Other Algae: 44/100 gals, few species; predominantly Chlorophytes, some Hydrurus</p> <p>Diatoms: 236/100 gals, few species; predominantly Pennales, including Navicula</p> <p>Plant Debris: None Detected (ND)</p> <p>Giardia: ND</p> <p>Coccidia: ND</p> <p>Rotifers: ND</p> <p>Nematodes: ND</p> <p>Pollen: ND</p> <p>Ameba: ND</p> <p>Ciliates: ND</p> <p>Colorless Flagellates: ND</p> <p>Crustaceans: ND</p> <p>Insects/Larvae: ND</p> <p>Other: ND</p>

ANALYSIS FOR WATERBORNE PARTICULATES

CHDiagnostic and Consulting Service, Inc.
1966 W. 15th St, #4, Loveland, CO 80538
Carrie M. Hancock, President Telephone (970) 667-9789

Invoice 952168

4/14/95

Customer 950703

Terracon Consultants Western, Inc.
3711 Regulus Drive
Las Vegas, NV 89102

PWSID#

Laboratory Information

UPS; 4/14/95; 1030 Hrs;
Polypropylene; Excellent; Results
submitted by:

Carrie M. Hancock

Sample Information: Water Well, NPS Well - 1, Source: Drilled well, 200' deep & 300' from
river/stream/lake, unchlorinated; 25.2°C, pH 6.97, 1.42 NTU

Date/Start: 4/12/95; 1415 Hrs

Date/Stop: 4/13/95; 0900 Hrs

Sampler: Stefan Hoffman

Gallons: 1085.3

Filter Color: Rust

Centrifugate: 1.2 mL/100 gals

Amorphous Debris: Silica, inorganic precipitate & sand, 1-100 µM diameter

Other Algae: 44/100 gals, few species; predominantly Chlorophytes, some Hydrurus

Diatoms: 236/100 gals, few species; predominantly Pennales, including Navicula

Plant Debris: None Detected (ND)

Giardia: ND

Coccidia: ND

Rotifers: ND

Nematodes: ND

Pollen: ND

Ameba: ND

Ciliates: ND

Colorless Flagellates: ND

Crustaceans: ND

Insects/Larvae: ND

Other: ND

This sample was analyzed for particulates following the Environmental Protection Agency Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA). All limitations stated in the method apply.

Comments: Score: 25 - High Risk per EPA Consensus Method referenced above.

TABLE 2. Relative surface water risk factors associated with scoring of primary bio-indicators (particulate) present during MPA of subsurface water sources.

Indicators of surface water ¹	Relative Risk Factor ²				
	EH ²	H	M	R	NS
Giardia	40	30	25	20	0
Coccidia	35	30	25	20	0
Diatoms	16	13	11	6	0
Other Algae	14	12	9	4	0
Insects/Larvae	9	7	5	3	0
Rotifers	4	3	2	1	0
Plant Debris	3	2	1	0	0

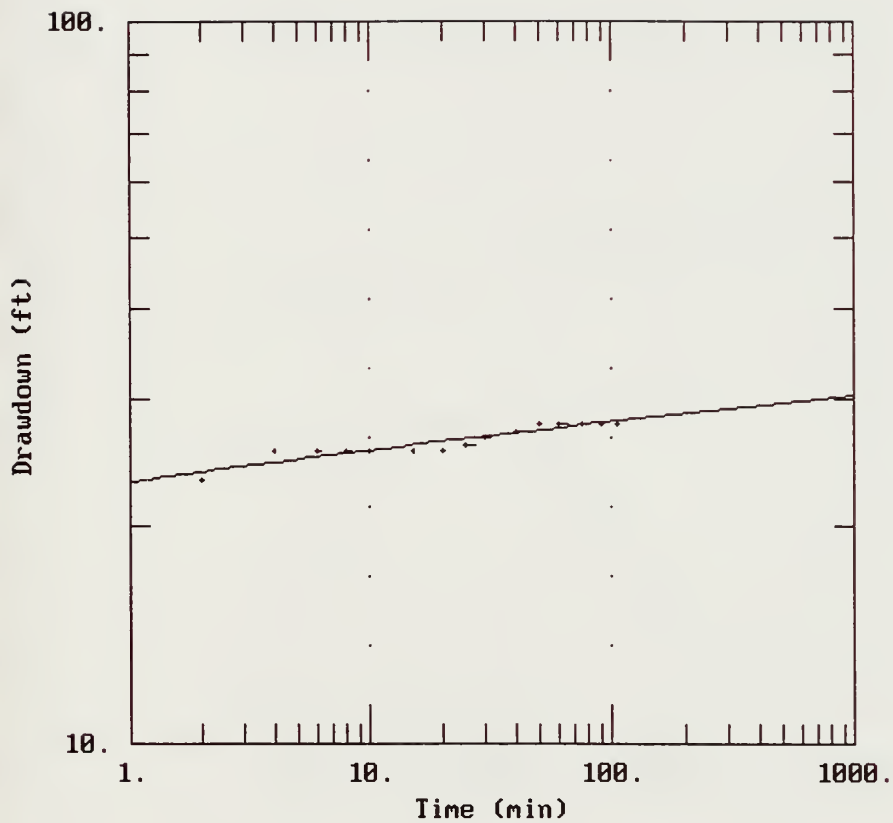
1. According to EPA "Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources", March 1991 ed.

2. Refer to Table 1 for range of indicators counted per 100 gallons.

Key= EH -extremely heavy M -moderate NS -not significant
 H -heavy R -rare

3. Risk of surface water contamination:
 ≥20 - high risk
 10-19 - moderate risk
 ≤9 - low risk

Mail Results To:



DATA SET:
NPS2.DAT
05/16/95

AQUIFER MODEL:

Leaky

SOLUTION METHOD:

Hantush (no stor.)

TEST DATA:

$Q = 100.$ gal/min

$r = 0.$ ft

$r_c = 0.25$ ft

$r_w = 0.41$ ft

$b = 1.$ ft

PARAMETER ESTIMATES:

$T = 1.013$ ft²/min

$S = 4.158E-09$

$r/B = 0.1$

BUREAU CHIEF
687-6353

ENVIRONMENTAL HEALTH
687-4750

ENGINEERING
687-4754



DRINKING WATER PROGRAM
687-6615

MILK PROGRAM
687-3787

RADIOLOGICAL HEALTH
687-5394

STATE OF NEVADA
DEPARTMENT OF HUMAN RESOURCES
HEALTH DIVISION

BUREAU OF HEALTH PROTECTION SERVICES
505 E. King Street, Room 103
Carson City, Nevada 89710

BOB MILLER
Governor

YVONNE SYLVA
Administrator

CHARLOTTE CRAWFORD
Acting Director

DONALD S. KWALICK, M.D., M.P.H.
State Health Officer

May 18, 1995

ROBERT F KAUFMANN CEM CEG
VICE PRESIDENT
TERRACON CONSULTANTS WESTERN INC
3711 REGULUS DRIVE
LAS VEGAS NV 89102

RE: LAKE MEAD RECREATION AREA, CALLVILLE BAY TEST WATER SUPPLY WELL

Dear Mr. Kaufmann:

We have reviewed your May 2, 1995 submittal concerning the location, construction characteristics, and water quality results for a test water supply well recently constructed at Callville Bay Marina. You requested that we indicated a) what additional water treatment, if any, might apply, b) the variance procedures, if any, to allow use of the water despite it not meeting certain secondary standards, and c) whether the groundwater developed from this well appears to be under the direct influence of surface water.

The following is the response to these items:

1. Community water systems must provide water that meets all primary drinking water standards as contained in Nevada Administrative Code (NAC) Chapter 445, Public Water Systems Quality. Exceedance of a primary or secondary standard may require public notification, treatment, and/or additional monitoring as deemed necessary by the health authority.
2. The State Board of Health may grant a variance or exemption from a primary drinking water standard in accordance with NAC Chapter 445, Public Water Systems Quality. The State Board of Health may grant a variance from a secondary drinking water standard in accordance with the procedures for seeking variances set forth in chapter 439 of NAC.

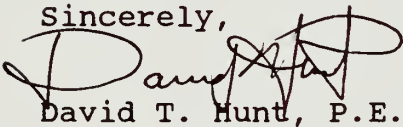
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3. The groundwater developed from this source appears to be under the direct influence of Lake Mead. The water well siting investigation has indicated that the aquifer is recharged by Lake Mead. The water quality data, particularly the Microscopic Particulate Analysis, concluded that the groundwater is a high risk pursuant to the Environmental Protection Agency Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis. It should be emphasized that surface water influence on a groundwater source cannot be determined solely on the basis of one MPA. If a ground water source is determined to be under the direct influence of surface water, the source would be subject to the requirements of NAC Chapter 445, Public Water Systems Surface Water Treatment Rule (SWTR).

NAC Chapter 445, Public Water Systems Quality, NAC Chapter 445, Public Water Systems SWTR, and NAC Chapter 439, Variances From Regulations of State Board of Health can be purchased from this office or the Las Vegas office of the Bureau of Health Protection Services for \$6.00, \$6.00, and \$2.00, respectively.

If you have any questions, please contact me at 687-6615.

Sincerely,



David T. Hunt, P.E.
Public Health Engineer
Bureau of Health Protection Services

cc: Richard Reighley, Public Health Engineer

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